NATIONAL ECONOMIC IMPACTS

FROM THE DOD SBIR/STTR PROGRAM

1995–2018

EXECUTIVE SUMMARY

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are the U.S. government's primary mechanism for engaging small technology businesses in research and development (R&D) to benefit the nation. The Department of Defense (DoD) accounts for approximately 50 percent of all federal SBIR/STTR funds.

This study quantifies the DoD SBIR/STTR Program's overall contribution to the nation's economy and defense mission. It examines the economic outcomes and impacts up to 2018 from DoD SBIR/STTR Phase II contracts initiated during the 1995-2012 fiscal year (FY) period, providing definitive answers to the question: *What resulted from the DoD's investment of $14.4 billion in small business R&D funding provided to companies nationwide via 16,959 separate SBIR/STTR Phase II contracts?*

The study was conducted by TechLink, a national DoD partnership intermediary at Montana State University-Bozeman, in collaboration with the Business Research Division of the Leeds School of Business at the University of Colorado in Boulder.

The research team developed innovative strategies to contact all 4,412 companies that initiated DoD SBIR/STTR Phase II contracts during the study period. Companies were asked to divulge the total sales of new products and services directly related to their DoD SBIR/STTR Phase II contracts. They also were asked about related economic outcomes, including sales to the U.S. military, follow-on R&D contracts, licensing revenue, and sales by licensees and spin-out companies. Companies provided comprehensive information on the economic outcomes for 96 percent of the contracts. The research team was able to obtain full or partial information on other contracts through secondary research. In all, this study presents the economic outcomes of 16,516 of the 16,959 DoD SBIR/STTR contracts—over 97 percent.

Well over half of the DoD Phase II contracts—58 percent—resulted in sales of new products and services based on the innovations developed under these contracts. IMPLAN economic impact modeling software was used to estimate the overall effects on the U.S. economy from both the R&D expenditures and subsequent sales of SBIR/STTR-developed products and services. Study results are believed to significantly understate the actual economic impacts because of non-responding companies, the effects of inflation, and other factors analyzed in the report. *Major findings include the following:*

$121 BILLION IN TOTAL SALES OF NEW PRODUCTS AND SERVICES

22:1 RETURN ON THE DOD INVESTMENT

$28 BILLION IN SALES OF NEW PRODUCTS TO THE U.S. MILITARY

$347 BILLION IN TOTAL ECONOMIC IMPACT NATIONWIDE

1,508,295 JOBS (65,578 PER YEAR) WITH AVERAGE COMPENSATION OF $73,461

PURPOSE OF STUDY

This study was undertaken to quantify the DoD SBIR/STTR Program's overall contribution to the national economy and the nation's defense mission.[1] The study examined the economic outcomes and impacts up to 2018 from all DoD SBIR/STTR Phase II contracts initiated during the 1995-2012 FY period. This time period includes all Phase II awards since 1995 that realistically could have generated any significant economic impacts by the time of the study. The overriding question was: *What resulted from the DoD's SBIR/STTR investment of approximately $14.4 billion in Phase II awards, provided to 4,412 companies in 16,959 separate SBIR/STTR contracts?*[2]

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1 The federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are similar. However, STTR programs require small businesses to formally collaborate with not-for-profit research institutions, such as universities, and are much smaller in size, reflecting a smaller percentage of federal budget allocation. See *www.sbir.gov*.

2 The amount of the DoD's SBIR/STTR Phase II investment was slightly over $14.35 billion, with an additional $1.62 billion in previous DoD Phase I awards that established the foundation for these Phase II contracts. The actual number of named award recipients was originally higher, but was reduced by mergers and acquisitions. Appendix 2 provides a breakdown of the DoD SBIR/STTR Phase II contracts by state.

Primary objectives were (1) to determine the extent to which the DoD SBIR/STTR Program has contributed to new economic activity and job creation in the United States; and (2) to assess the program's effectiveness in generating new technology for U.S. military use. The DoD Office of Small Business Programs commissioned the study.

SBIR Success Story

A DARPA SBIR helped Ahmadreza "Reza" Rofougaran develop the integrated networking chips that still drive the lion's share of today's wireless technology.

With more than 800 patents to his name, Dr. Ahmadreza "Reza" Rofougaran is one of the most prolific inventors in history. His name appears on scores of scholarly journals, and his ideas have transformed the way we communicate. To get an immediate sense of the impact of his work, however, you need look no further than your own pocket.

Rofougaran has played an outsized role in today's mobile revolution. Funding from the DARPA SBIR program helped Rofougaran pioneer the technologies that enable the wireless connectivity found in virtually every smartphone, tablet, and computer. By developing the technology that ultimately allowed a single, inexpensive chip to connect via WiFi, Bluetooth, and GPS, Rofougaran made smartphones capable of everything from browsing the Internet and providing driving directions to beaming music to wireless headphones.

THE DOD SBIR/STTR PROGRAM IN CONTEXT

SBIR programs originated with federal legislation in 1982 and were created expressly to harness the innovativeness of U.S. small business—both to help the federal government meet high-priority technology needs as well as to benefit the national economy. Establishment of these programs was part of a larger effort in the United States during the early 1980s to make strategic R&D investments to counter the loss of national economic competitiveness.

The enabling legislation for these programs, the Small Business Innovation Development Act of 1982,[3] was based on the conviction that technological innovation creates jobs and increases productivity, competitiveness, and economic growth. It also was predicated on the belief that small businesses are the principal source of innovation in the United States. The 1982 Act was designed to achieve four major economic objectives:

- Spur technological innovation in the United States

3 Text available online at *http://history.nih.gov/research/downloads/PL97-219.pdf.*

- Help meet federal government R&D needs
- Increase private sector commercialization of innovations resulting from federally funded investments
- Encourage participation by minority and disadvantaged persons in technological innovation

All federal agencies with extramural R&D budgets that exceed $100 million (currently 11 agencies) are required to allocate a small portion of their R&D budgets to SBIR. The designated amount in FY 2018 was 3.2 percent. In addition, the five federal agencies with extramural R&D budgets exceeding $1 billion (Department of Defense, Department of Energy, Department of Health and Human Services, National Aeronautics and Space Administration, and National Science Foundation) are required to expend a very small portion of their extramural R&D budgets on STTR. That amount was 0.45 percent in FY 2018.

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Each agency determines its own R&D topics, issues solicitations, accepts proposals from small businesses (defined as for-profit entities with not more than 500 employees), establishes evaluation processes for these proposals, and makes awards on a competitive basis. The Small Business Administration (SBA) functions as the overall coordinating agency for both SBIR and STTR.

There are three phases to SBIR/STTR programs. *Phase I* funds short-term (typically six-month) feasibility studies of proposed innovations. These awards usually have a $150,000 cap, depending on the agency, but can be up to $225,000 and even larger with special SBA approval. Assuming that a company establishes the scientific and technical merit as well as the commercial potential of its proposed innovation, it can compete for follow-on Phase II funding. *Phase II* provides continued R&D funding for successful Phase I projects and frequently results in development of a prototype. Phase II awards usually have a $1 or $1.5 million cap, and are typically for a two-year R&D effort. *Phase III* includes any follow-on, non-SBIR/STTR

funding for further specialized R&D or transition of technologies developed during the previous phases to government acquisition programs. Some federal agencies provide supplemental funding for further development of promising innovations when they demonstrate strong commercial potential or the capability to meet critical U.S. government technology needs.

Approximately $2.4 billion is awarded annually through the federal SBIR/STTR programs. DoD is the largest participant, with approximately $1.3 billion in SBIR/STTR contracts annually—about half of all federal SBIR/STTR funding. In FY 2017, DoD budgeted a total of $1.37 billion for its SBIR/STTR programs, broken down as follows: $1.2 billion for SBIR and $169 million for STTR. Within DoD, there are 13 different components with individual SBIR/STTR programs. Table 1 shows the comparative sizes of these different programs based on their published FY 2016 budgets.

Table 1: DoD SBIR and STTR Programs, FY 2016 Budgets

DoD Component	SBIR/STTR Total ($ *millions*)	SBIR Total ($ *millions*)	STTR Total ($ *millions*)
Navy	365	317	48
Air Force	337	293	44
Army	211	190	21
DARPA	89	78	12
MDA	89	77	12
DHP (now DHA)	73	63	10
CBD	19	17	3
SOCOM	16	14	2
DTRA	11	9	1
DLA and DMEA	6	5	1
OSD	1	1	0
NGA	0	0	0

Source: DoD Office of Small Business Programs

Note: Totals may not tally due to rounding

Photo by Master Sgt. Becky Vanshur

IMPORTANCE OF THE STUDY

This study is the first-ever comprehensive analysis of the economic impacts of an entire federal agency SBIR/STTR program. It uses the well-established national IMPLAN model to estimate two key impacts of the overall DoD SBIR/STTR program: (1) The impacts directly related to the SBIR/STTR R&D activity itself; and (2) the impacts related to the subsequent commercialization of the innovations developed with these awards. Given the preeminent size of the overall DoD SBIR/STTR program and the fact that it funds innovations in virtually all technology fields, this study's results have major relevance to the entire federal SBIR/STTR enterprise.

The current study builds on previous studies by the same research team. In 2015, TechLink finalized a study of all Air Force SBIR/STTR Phase II contracts completed between 2000 and 2013.[4] Subsequently, in 2016, it finalized a similar study for the Navy covering Navy SBIR/STTR Phase II contracts specified as completed during the same 2000-2013 period.[5]

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4 TechLink, 2015. National Economic Impacts from the Air Force SBIR/STTR Program, 2000-2013. Text available online at *https://www.sbir.gov/node/832335*.

5 TechLink, 2016. National Economic Impacts from the Navy SBIR/STTR Program, 2000-2013. Text available online at *https://www.sbir.gov/node/832335*.

This study builds and expands on those previous studies in three key ways. First, it encompasses *all thirteen DoD components* with SBIR/STTR programs—those listed in Table 1. Second, it extends the study period back in time, to capture impacts from earlier awards, and also updates the results from the previous Air Force and Navy studies. Finally, IMPLAN modeling in this study includes the Phase I awards preceding the Phase II awards that are the primary focus, based on the premise that these Phase I awards generated economic activity and provided the essential foundation for the Phase II awards.[6]

In summary, this study quantifies the DoD SBIR/STTR Program's overall contribution to the nation's economy and defense mission and provides a comprehensive answer to the overriding question: *What resulted from the DoD SBIR/STTR investment of approximately $14.4 billion in Phase II R&D projects initiated by over 4,400 small businesses?* Looked at more broadly, it also addresses the question of how successful the DoD has been at achieving the major economic goals of the federal SBIR/STTR mandate—spurring technological innovation, helping meet federal government R&D needs, and achieving private-sector commercialization of innovations from federal funding investments.[7]

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6 Phase I awards associated with these Phase II contracts totaled $1.62 billion.

7 The study did not address the federal SBIR/STTR mandate's fourth goal: to encourage participation by minority and disadvantaged persons in technological innovation.

SBIR Success Story

Ekso Bionics has transformed the wearable robotics industry

By mid-2017, California-based Ekso Bionics had 30 U.S. patents and nearly 200 international patent cases (granted or pending). Much of that intellectual property resulted from a series of SBIR and STTR contracts from various DoD programs. This funding has enabled Ekso Bionics to develop exoskeletons that not only help paralytics walk but also amplify American war-fighter strength and performance.

RESEARCH TEAM

This economic impact study was conducted by TechLink, a DoD-funded technology transfer center at Montana State University-Bozeman, in collaboration with the Business Research Division (BRD) of the Leeds School of Business at the University of Colorado Boulder.

Since 1999, TechLink has served as DoD's primary national "partnership intermediary," helping to develop technology transfer partnerships between DoD laboratories and U.S. industry nationwide. TechLink's primary focus is helping DoD labs transfer their inventions to U.S. companies through license agreements. TechLink annually brokers or facilitates over 70 percent of all DoD license agreements with industry. These license agreements enable companies to develop, manufacture, and sell products and services that incorporate DoD inventions. TechLink maintains the only complete database of DoD patents, searchable by industry for technology licensing opportunities. TechLink has also provided extensive SBIR support since 2000, both within Montana, covering all federal agencies, and nationwide for DoD, focusing

primarily on facilitating Phase II and III contracts leading to transition of critically needed military technologies. In addition, TechLink regularly undertakes economic impact studies of DoD technology transfer and SBIR programs; conducts "innovation discovery" workshops to help DoD labs identify and protect their inventions; and develops articles and videos of DoD technology transfer and SBIR success stories. (For more information, see *http://techlinkcenter.org* and *http://www.montana.edu/techlink*.)

The BRD has been analyzing local, state, and national economies for more than 100 years. It specializes in customized research and economic impact studies that help companies, associations, nonprofits, and government agencies make informed business and policy decisions. The BRD has conducted economic impact studies for a wide range of clients, including the National Renewable Energy Laboratory, Xcel Energy, Western Union, the American Petroleum Institute, and CO-LABS, a consortium of federally funded scientific laboratories, universities, businesses, and local governments in Colorado. (For more information, see *https://www.colorado.edu/business/business-research-division*.)

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This is the ninth major economic impact study undertaken by TechLink and the sixth study it has conducted with the BRD.[8] The principal authors are Dr. Will Swearingen and Ray Friesenhahn of TechLink, and Brian Lewandowski and Dr. Richard Wobbekind of the BRD.[9]

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8 These studies are available online at *http://techlinkcenter.org/EIS*.

9 Other key members of the TechLink team were Chris Huvaere, who created and managed the study's custom database; Jeff Peterson, who ensured the accuracy of the database entries and participated in analysis of the survey results; and Joe Hutton, Jessica Kaplin, Ann Peterson, John Verostek, and Michael Wallner, who contacted the companies in the survey to ask about their Phase II SBIR/STTR project results. They were assisted by several capable subcontractors, including Alexandra Amonette, Christie Bell, Juliane Bergmann, Naomi Engleman, Chris Mehus, Kari Oelkers, Andrew Schoneberg, and Jim Wasson.

METHODOLOGY

This study was undertaken in three major phases. First, during the *data gathering* phase, the research team attempted to contact all companies that initiated DoD SBIR/STTR Phase II projects during the FY 1995-2012 time frame. Companies were asked to divulge the total sales of new products and services and other economic results directly related to these SBIR/STTR contracts. This phase lasted for approximately 20 months, from November 2016 through the end of June 2018.

Second, during the *data analysis* phase, the research team processed and analyzed the information gathered, ensuring it met the highest standards for quality and consistency, used conservative estimates, and included only U.S. economic impacts.[10] The team then used IMPLAN economic impact assessment

10 In cases where the research team learned or suspected that product manufacturing or other production activities were occurring outside the United States (such as electronics manufacturing in overseas foundries), the team conducted in-depth, follow-up assessments. Foreign production activities were eliminated from inclusion in the study's economic impacts.

software to estimate the total economic impacts resulting from (1) the SBIR/STTR funding for R&D, including all Phase II awards and the initial Phase I funding for these same awards, and (2) subsequent sales of new products and services derived from the resulting innovations. This second phase took approximately five months and extended from July 2018 through November 2018. The *final report generation* phase extended from November 2018 through January 2019. Specific activities undertaken during the first two phases are subsequently described.

Data Gathering

To enable TechLink to undertake this study, the DoD Office of Small Business Programs provided essential information on DoD SBIR/STTR Phase II contracts initiated during the FY 1995-2012 period. This reflected decisions made by the TechLink research team, in consultation with the Office of Small Business Programs, to *change the approach* previously used in economic impact studies of the Air Force and Navy SBIR/STTR programs.

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These previous two studies had focused on Phase II awards completed during the 2000-2013 period. While conducting these studies, TechLink noticed that certain pre-2000 Phase II awards seemed to have generated large economic impacts. There was a desire to capture these impacts. However, extending the study period further back in time involved a tradeoff. Generally, the older the award, the more difficult it is to gather information on its outcomes. After consideration, the team selected 1995 as a reasonable start date under the assumption that results for even earlier awards would be too difficult to track down with any consistency.

In addition, the previous Air Force and Navy SBIR/STTR studies had used *completion dates* for the Phase II projects, rather than contract *initiation dates.* However, that approach had occasionally resulted in complications. Many Phase II contracts received supplemental funding or no-cost extensions that changed end dates up to several years. The research team believed that contract *start dates* would provide a more consistent measure for analysis than end dates. The DoD Office of Small Business Programs agreed with this approach.

The team selected 2012 as the cutoff year for new Phase II contracts because TechLink's prior studies had shown little or no commercialization occurring until at least three years after

a Phase II project had been completed. Phase II projects originating *after* 2012 would normally be completed in 2015 or later. As a result, they would not have had enough time to generate any significant sales when this new study was launched in fall 2016. In short, the current economic impact study included all DoD Phase II awards since 1995 that realistically could have generated any significant commercial or military impacts.

In reviewing the dataset on DoD SBIR/STTR Phase II contracts provided by the DoD Office of Small Business Programs, TechLink staff subsequently discovered that it was missing around 120 Phase II awards. These missing awards were first verified by the existence of a relevant Phase I award, then by at least two independent sources confirming the Phase II contract, such as DoD SBIR/STTR Company Commercialization Reports (CCR), the Federal Procurement Data System (FPDS), or the SBIR/STTR recipient companies themselves. The 120 missing records were added to the project database.

Conversely, the research team discovered that around 130 Phase II contracts were erroneously included in the DoD SBIR/STTR database. This was discovered in part by comparing that database with the Air Force and Navy SBIR/STTR databases provided by those components and used by TechLink in its earlier economic impact studies. Most were contracts that were entered twice in the database due to contract number errors, misidentified Phase I awards, and start dates outside the study parameters (mostly delayed starts until 2013 or 2014). However, some of these contracts were actually never awarded or were subsequently terminated or rescinded. After careful vetting, all of these erroneous contracts were removed from the database. The survey focused

SBIR Success Story

An SBIR-supported technology allows for quick diagnosis of brain injuries

Created by Infrascan, Inc., a revolutionary handheld device called Infrascanner allows for on-the-spot brain injury assessments, benefiting both U.S. military and civilian trauma cases. Developed with support from the Department of Defense's SBIR program, Infrascanner emits harmless near-infrared light into the outer layers of a patient's skull. The device then measures differences in light absorption, indicating where bleeding may be occurring. Results are displayed on the device's built-in screen, enabling timely medical decisions that save lives.

exclusively on Phase II contracts because Phase I contracts are strictly intended to investigate the feasibility of new technology concepts. Unless followed by subsequent Phase II funding, Phase I contracts rarely lead to new commercial products and services. The study included a total of 16,959 Phase II contracts awarded to 4,412 different companies.

Information provided for each Phase II contract was entered into a custom database developed for this study in order to facilitate data gathering and analysis. Essential Phase II contract information included the company name and location; the contract number and award amount; the start and completion dates of the award, including any contract extensions; and the names and contact information for the principal investigator and company executive at the time of the award. Award titles and abstracts, which provide background information on the technology being developed, helped establish connections to any resulting commercial technologies, and were especially useful when interviewing companies with multiple SBIR/STTR awards.

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TechLink economic research specialists used the Phase II information and database to survey the companies involved. They attempted to contact, by email and telephone, all 4,412 Phase II recipients about the outcomes of their 16,959 DoD Phase II contracts. The number of contracts exceeds the number of companies because a sizeable subset of companies included in the study (2,157, or 49 percent) had two or more DoD SBIR/STTR Phase II contracts during the study period. In fact, 344 companies (8 percent) had 10 or more DoD Phase II contracts, and 31 (less than 1 percent) had 50 or more contracts. Ten of the most active participants in the DoD program had 100 or more Phase II contracts, and one company had a total of 241 contracts included in the study. The average was 3.85 DoD Phase II awards per company.

Survey Questions

Companies were asked a series of questions that focused on the economic outcomes and impacts related to their DoD SBIR/STTR Phase II contracts. They were assured that their responses would be treated as confidential information and that, in order to conceal their identity,

their responses would be aggregated with the responses of other companies and submitted to the DoD without company names. Basic questions included the following:

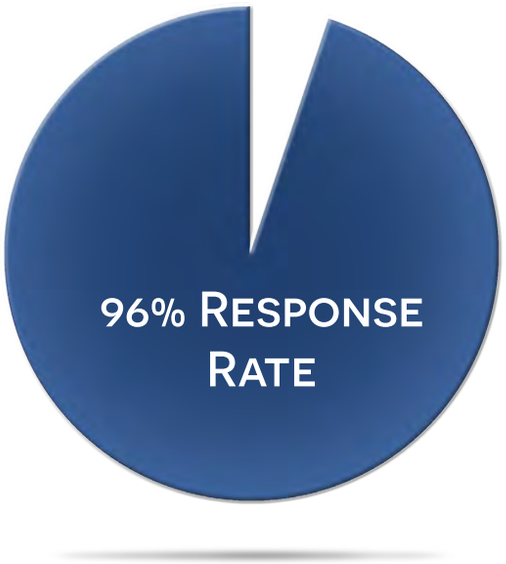
- Did your company develop any new products or services based on your DoD SBIR/STTR Phase II contract(s)? If so, what were the total cumulative sales of these new products or services for each contract?[11]

- What was the dollar value of sales to the U.S. military, either directly or through a prime contractor?

- Did the Phase II contract(s) lead to any follow-on R&D contracts (not including additional DoD SBIR/STTR awards) for further development of the technology or technologies resulting from Phase II? If so, what was the total dollar value of these contracts?

- Did you license any of the technologies developed with DoD Phase II funding to another company? If so, what were the total royalties received from each licensee? Please quantify, if possible, the total associated sales made by the licensee(s), and also provide the name(s) of the licensee(s) so we can follow up to ask about sales.

- Did you create a spin-out company to commercialize any of the technologies developed with DoD SBIR/STTR Phase II funding? Please quantify, if possible, the total associated sales made by the spin-out company, and provide the name of the company so we can contact its representatives about sales.



- Did you receive any significant subsequent investment funding, such as venture capital or angel funding, directly related to the technology developed or commercialized? If so, what was the total amount of these investments?

- Was your company acquired as a direct result of the technology or technologies developed with DoD SBIR/STTR Phase II funding? If so, what was the acquisition amount?

11 Companies were not asked to report their sales *by year* because this would have greatly increased the burden of responding to the survey and, consequently, lowered the response rate.

Response Rate

The response rate was 96 percent. Companies surveyed provided definitive information on the outcomes of 16,244 contracts—96 percent of the 16,959 total. However, TechLink researchers were able to obtain full or partial sales information on 272 additional contracts from other official sources.[12]

Including this secondary research, the study obtained authoritative information on the outcomes of 16,516 (over 97 percent) of the DoD Phase II contracts. Results from only 443 contracts remain unknown.[13]

The primary reasons for the study's high response rate are believed to be the following:

- *Clear communication about the purpose and legitimacy of the study*. Companies were informed that the study's purpose was to quantify the extent to which the DoD SBIR/STTR Program was having a positive impact on the national economy and U.S. defense mission, and that the results would be communicated to DoD policymakers, other government agencies, Congress, and the U.S. public. Companies that questioned the legitimacy of the study were sent a letter from the director of the DoD Office of Small Business Programs that explained the purpose, confidential nature, and importance of the study as well as TechLink's role in undertaking it. They also were referred to the TechLink website, where they could find information about the study and research team, view prior economic impact studies, and download a copy of the DoD letter.

- *Strong assurance that company-specific information would be kept confidential*. Companies were assured that the DoD was only interested in the overall economic impacts from its SBIR/STTR Program—not in company-specific results. Most companies consider their sales figures to be confidential, proprietary, or business sensitive. Without the assurance that all

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12 These other official sources included Company Commercialization Reports (CCRs) and the Federal Procurement Data System (*www.fpds.gov*). Companies are now required to submit a CCR with every SBIR or STTR proposal submitted to the DoD, although requirements have varied since 1995. CCRs are intended to provide a record of prior Phase II projects and the sales and investment resulting from innovations developed under these projects. The Federal Procurement Data System (FPDS) is a database of government contracts. It is managed by the Federal Procurement Data Center, part of the U.S. General Services Administration, and contains detailed information on all government contracts exceeding $3,000.

13 Only 126 (less than 3 percent) of the 4,412 DoD Phase II recipient companies either openly refused to participate in the study or were non-responsive. An additional 172 companies (3.9 percent) could not be surveyed because they could not be contacted; they had ceased to exist, changed their names, or been acquired by other companies and left no trails that could be followed. In short, the research team was able to obtain comprehensive economic information from 93 percent of the companies in the study, covering 96 percent of the total contracts.

responses would be treated as business confidential information, few companies would have been willing to divulge their sales information.

- *Extensive research to find current contact information.* Because of the long time span covered by the study and the impermanent nature of many small R&D companies, the contact information for principal investigators and company executives in the DoD SBIR/STTR awards database was no longer valid in many cases. Among other things, telephone area codes had changed; companies had gone out of business, relocated, or merged with other firms; and the key people had changed positions, moved to other companies, retired, or even died. The research team expended extensive time and effort to find people knowledgeable about the outcomes of the DoD SBIR/STTR Phase II contracts.

- *Persistence by the TechLink economic research specialists*. Some companies were contacted more than a dozen times by email, LinkedIn, and telephone in an attempt to reach the right person and obtain the necessary information. Several different approaches were tried to secure compliance from recalcitrant companies, including having other team members contact the company and approaching different company personnel. In cases of both non-responsive companies and companies that were no longer in business, efforts were made to track down former employees who could provide definitive information on the economic outcomes from the DoD Phase II awards. This sometimes required the pursuit of dozens of potential contacts before someone knowledgeable and willing to participate was located.

- *Conciseness of the survey.* The survey questions were relatively few in number and easy to answer. In some cases, the research team was able to secure the necessary information over the telephone on the first contact. More commonly, extensive follow-up by phone and email was required, often involving several different company personnel. This was especially true with companies having numerous DoD SBIR/STTR awards. However, the conciseness of the survey encouraged participation.

NAICS Code Assignments

TechLink assigned all Phase II contracts to the appropriate 6-digit North American Industry Classification System (NAICS) code or codes.[14] NAICS is the U.S. federal government's standard industry classification system. It recognizes 1,065 different industrial activities and assigns a unique code to each. NAICS codes can be found at the U.S. Census Bureau's NAICS code website at *http://www.census.gov/eos/www/naics/*.

14 See Appendix 1 for the NAICS codes assigned to contracts in the study.

NAICS codes are one of the most important inputs to the IMPLAN economic impact model (described below), and assigning the right codes was an essential step for accurate analysis of the overall economic impacts from the DoD SBIR/STTR Program. IMPLAN uses NAICS codes to determine the economic multipliers associated with specific business activities. These multipliers are based on spending patterns unique to each industry and region.

To ensure accuracy, the research team carefully considered the specific technology and associated economic activity (product or service) resulting from the DoD SBIR/STTR funding, rather than relying on the NAICS code(s) normally assigned to the small business in question. Often, this NAICS code was different than the company's primary NAICS code.

For accurate analysis of the economic impacts resulting from the Phase II R&D activity, all contracts were assigned one of the following four primary R&D NAICS codes, listed by order of frequency:

- 541715: Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)
- 541714: Research and Development in Biotechnology (except Nanobiotechnology)
- 541713: Research and Development in Nanotechnology
- 541720: Research and Development in the Social Sciences and Humanities

Many companies received follow-on funding to further develop their DoD SBIR/STTR innovations for specialized government or industry applications. In such cases, they were assigned the appropriate R&D NAICS codes for that research. In addition, if the R&D led to commercial sales or other economic outcomes from the resulting innovations, the research team assigned NAICS codes specific to those economic activities. Some were assigned two or more commercial sales-related NAICS codes. For example, if as a result of its DoD SBIR research, a company both manufactures oil-free air bearings for use on unmanned aerial vehicles, and also provides life testing services for air bearings, it would be assigned two different NAICS codes for these different business activities.

The research team used Phase II contract information, data provided by companies during the survey, and the NAICS classification system to identify the appropriate NAICS codes for sales of products or services. In this process, the team relied heavily on the Census Bureau's NAICS code website at *www.census.gov/eos/www/naics/*. Additional resources consulted included the federal System for Award Management (*www.sam.gov*), D&B Hoovers (*www.hoovers.com*), and the LexisNexis Academic web site (*www.lexisnexis.com*).

Researchers regularly consulted with each other and with senior staff familiar with both NAICS codes and general technology categories and applications to help identify, confirm, and double-check NAICS codes to assure their accuracy.

Next, the TechLink research team entered company sales and other economic data as well as the NAICS code information into the custom database developed for this study. This database was designed to immediately flag potentially conflicting entries, thereby reducing errors. It greatly facilitated data entry from the multiple economic research specialists interviewing companies, and included sections for explanatory notes to facilitate later review and quality assurance checks by supervisory staff. Once the data were aggregated and carefully validated, the database enabled the research team to quickly query and analyze the survey results as well as to generate a final dataset for economic impact modeling.

Experienced senior staff carefully reviewed a large percentage of all records, particularly those with substantial sales figures, to ensure that they were consistent and justifiable, and that conservative numbers were used when a range of sales figures were provided by the company. One important concern was ensuring that only U.S. economic impacts were included. When firms in the study were acquired by foreign corporations, research was undertaken to determine if production was moved outside the United States. If so, any sales after that point were not included. In one case, an advanced treatment process for U.S. military aircraft engines was found to be performed in Canada, so those results were excluded. In several cases, DoD SBIR/STTR-developed technologies were incorporated into microelectronic chips, which were suspected to be produced in overseas foundries. In those and similar cases, annual corporate reports and other sources were investigated to determine where production occurred. If the manufacturing location was not in the United States, the Cost of Goods Sold (or equivalent) was used to reduce the sales figures reported by the companies.


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TechLink subsequently submitted the final dataset to the BRD at the University of Colorado Boulder. For each DoD SBIR/STTR Phase II contract, the dataset included a code number to identify the record and conceal the company's name, the NAICS code for the company's SBIR/STTR research activities, the NAICS code for any resulting product or service, and the total sales figures.

The "sales" category included all sales of new products and services directly related to the technologies developed with the DoD SBIR/STTR funding up to the time of the study (2016-2018), including military sales; follow-on R&D contracts to further develop these technologies for specific applications (defined as sales of R&D services); royalties from licensees of the technologies developed with the DoD SBIR/STTR funding; licensee sales of the licensed DoD SBIR/STTR-developed technologies; and sales by spin-out companies of the DoD SBIR/STTR-developed technologies.

Data Analysis

The BRD employed the widely used economic impact analysis software program IMPLAN to estimate the economic contribution effects of the total sales resulting from the DoD SBIR/STTR Phase II contracts. More than 1,500 entities in academia, the private sector, and government use IMPLAN to model economic impacts. It is employed to determine economic impacts on regions ranging in size from zip code area to county, state, and national levels (*www.implan.com*).

IMPLAN draws on a mathematical input-output framework originally developed by Wassily Leontief, the 1973 Nobel laureate in economics, to study the flow of money through a regional economy. IMPLAN assumes fixed relationships between producers and their suppliers, based on demand, and that inter-industry relationships within a given region's economy largely determine how that economy responds to change. New or increased demand for a certain product or service causes a multiplier effect—a cascade of ripples through the economy. This affects the producer of the product, the producer's employees, the producer's suppliers, the supplier's employees, and others, ultimately generating a total impact on the economy that significantly exceeds the initial change in demand.

For example, TranXistor Corporation (hypothetical company) uses its DoD SBIR Phase II funding to develop an ultra-high-performance carbon nanotube transistor. It then manufactures and sells these transistors for various government, industrial, and commercial applications. This requires TranXistor to hire factory workers, who spend their payroll checks on groceries and other goods. In addition, TranXistor has to purchase industrial machines, tools, electronic components, supplies, and packaging materials from other companies, which also employ workers who purchase groceries and other goods, extending the ripple of activity through the economy.

In this example, *direct effects* are the sales of the innovative carbon nanotube transistors developed with DoD funding. *Indirect effects* are the inter-industry purchases of machinery, components, and supplies needed to manufacture these transistors. *Induced effects* are the household expenditures as workers spend their payroll checks on goods and services across a wide spectrum of the economy. The total *economic impacts* are the sum of direct effects, indirect effects, and induced effects.

Multipliers are the ratio of the overall economic impact to the initial change and are typically derived from the following equation: (direct effect + indirect effect + induced effect) / direct effect. Multipliers are very specific to industry sectors and regions. IMPLAN uses NAICS codes to distinguish between 536 industry sectors recognized by the U.S. Department of Commerce. Each sector has a unique output multiplier because it has a different pattern of purchases from firms inside and outside of the regional economy. Each year, IMPLAN is updated using data

collected by various federal government agencies.

In this study, BRD converted the NAICS codes provided by TechLink to the 536-sector IMPLAN input-output model, then applied this model to (1) the DoD SBIR/STTR R&D activity, and (2) the total sales figures *up to the time of the study* (2016-2018) that were directly attributable to sales of the innovations resulting from the R&D activity. As previously indicated, these sales figures included all sales of products and services related to the DoD SBIR/STTR Phase II contracts initiated during the FY 1995-2012 period. Using IMPLAN, BRD was able to estimate the sum of the direct, indirect, and induced effects of these sales. The overall purpose of this modeling exercise was to estimate the total economic contribution of these sales to the nation's economy, including total economic output, value added, employment, labor income, and tax revenues.

Sales were assumed to be in 2017 dollars for IMPLAN modeling. Some of these sales dated back to the late 1990s. However, companies reported their aggregate sales up to the time that sales information was collected. There was a need to select a reference year for IMPLAN modeling. Use of 2017 as the reference year represents a conservative approach because it does not reflect the relatively higher value of the earlier sales figures due to inflation: a dollar in 2017 was worth 29 percent less than a dollar in 2000.[15]

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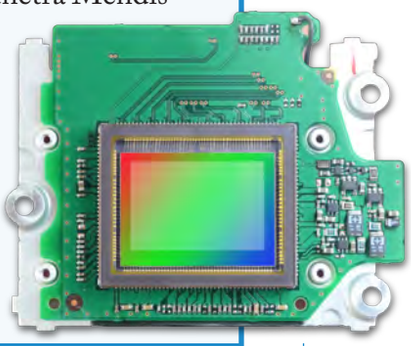
15 Per the U.S. Bureau of Labor Statistics, Consumer Price Index (CPI) Inflation Calculator, available online at *http://www.bls.gov/data/inflation_calculator.htm.*

SBIR Success Story

DoD SBIR contracts help develop CMOS imaging sensors used in phones and digital cameras

Innovator Eric Fossum, along with colleagues Sabrina Kemeny and Sunetra Mendis at Photobit Corp., developed an image sensor technology that was smaller, cheaper, and had greater power efficiency than previous technology. Their invention, the complementary metal oxide semiconductor (CMOS) active pixel sensor with intra-pixel charge transfer, led to the development of a better camera-on-a-chip—which can now be found in almost every new smartphone, digital camera, and computer.



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SURVEY RESULTS

Sales from DoD SBIR/STTR Phase II contracts

Well over half of the DoD SBIR/STTR Phase II contracts resulted in commercialization (see Table 2). Of the 16,959 Phase II contracts, 9,896 resulted in sales—58 percent of the total.[16] Of the rest, 6,620 did not result in sales and 443 consisted of contracts for which no information was available. Ultimately, the commercialization level achieved by these DoD SBIR/STTR Phase II contracts is likely to be significantly higher—it usually takes three to eight years to convert a new technology into a product. Many of the newer contracts have not yet resulted in sales.

16 This commercialization level is significantly higher than the 48 percent reported for DoD SBIR/STTR Phase II projects as a whole in the NRC study, National Research Council, 2014, *SBIR at the Department of Defense*, Washington, DC: The National Academies Press.

Table 2. Sales resulting from DoD SBIR/STTR Phase II contracts

DoD SBIR/STTR Phase II Contracts	Total Number of Contracts	Percent of Total
Contracts with sales	9,896	58
Contracts without sales	6,620	39
Contracts with unknown results	443	3
Total	16,959	100

Total cumulative sales of new products and services from the DoD SBIR/STTR Phase II contracts were over $121 billion.[17] This equates to average sales of approximately $12.2 million for each of the 9,896 contracts that achieved sales. The average sales per contract, when considering all of the DoD Phase II awards, including those without commercialization success, was approximately $7.1 million. This is over eight times the size of the average contract amount of $846,158, demonstrating that the DoD SBIR/STTR Program achieved substantial commercialization success from its funding of small R&D companies nationwide.

As previously noted, the "sales" category included all of the following sources of revenue from commercialization of the technologies developed with DoD SBIR/STTR Phase II funding:

- Sales of new products and services, including both commercial (civilian) sales and sales to the U.S. military
- Follow-on R&D contracts (not including DoD SBIR/STTR awards) to further develop these DoD SBIR/STTR-developed technologies for specific applications (these contracts were considered sales of R&D services)
- Royalties accruing to the DoD SBIR/STTR Phase II contract recipients from sales by licensees of the technologies developed with the DoD funding[18]

17 $121,045,941,804. This number likely understates the actual sales for the reasons discussed in the report.

18 In situations in which TechLink researchers obtained both royalty figures and licensee sales figures pertaining to the commercialization of a technology, the royalty payments were omitted from the impact model, to avoid double counting.

- Sales by licensees of the DoD SBIR/STTR-developed technologies—when this information could be obtained
- Sales by spin-out companies that were commercializing the DoD SBIR/STTR-developed technologies—when this information was available

Table 3. Sales from DoD SBIR/STTR Phase II contracts, by sales category

Sales Category	Total Sales $ Billions	Percent of Total
Commercial Product/Service Sales	$72.7	60
Military Product/Service Sales	$27.5	23
Follow-on R&D Contracts	$15.2	13
Royalties or Sales from Licensees	$1.8	1
Sales by Spin-out Companies	$3.9	3
Total	$121	100

Note: Totals may not tally due to rounding

Table 3 shows the sales from the DoD SBIR/STTR Phase II contracts, broken down by sales category. As this table shows, *commercial (civilian) product and service sales* were nearly $73 billion and accounted for 60 percent of the total sales. *Military product and service sales* were nearly $28 billion and constituted 23 percent of the total. These relatively high levels of sales indicate that the DoD SBIR/STTR Program is achieving the objectives of both private sector commercialization and development of new technology to support the U.S. defense mission.

Follow-on R&D contracts to further develop the technologies generated with DoD SBIR/STTR funding exceeded $15 billion and accounted for 13 percent of the total. This R&D funding came from both government and private sectors, and included Phase III contracts and non-DoD SBIR/STTR funding.

Royalties resulting from licensee sales of the technologies developed with DoD Phase II funding were around $813 million. This category is important because a significant number of companies engaged in SBIR/STTR research choose to remain R&D companies and license

successfully developed technologies to other companies for subsequent commercialization. *Sales by licensees* were reported to be $1.06 billion.[19] *Sales by spin-out companies* totaled $3.85 billion. Creating spin-out companies is another major way that companies engaged in SBIR/STTR research choose to commercialize SBIR-developed technology. Together, the last three categories accounted for approximately 4 percent of the total sales.

Figure 1 presents a graphic summary of the total sales from all DoD SBIR/STTR Phase II contracts that were initiated during the FY 1995-2012 period, broken down by sales category.

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19 "Royalties" and "Sales by Licensees" are combined in Table 3.

SBIR Success Story

Flexible solar panels create an off-the-grid power source for both civilians and warfighters

PowerFilm, a company based in Ames, Iowa, creates rollable and foldable solar panels for outdoor-recreation purposes, consumer electronics needs, and key military applications.

The properties of roll-to-roll amorphous silicon—the key technology behind PowerFilm's products—make it ideal for military applications. And while the company got initial funding from the Department of Energy, company president Dan Stieler credits SBIR contracts from DoD for PowerFilm's later accomplishments.

One of the key SBIR awards from the Army in 2002 helped PowerFilm develop foldable solar panels which could be incorporated into the fabric of military tents.

"The SBIR awards were really critical to PowerFilm's success and making it to the 30-year mark," Stieler said.

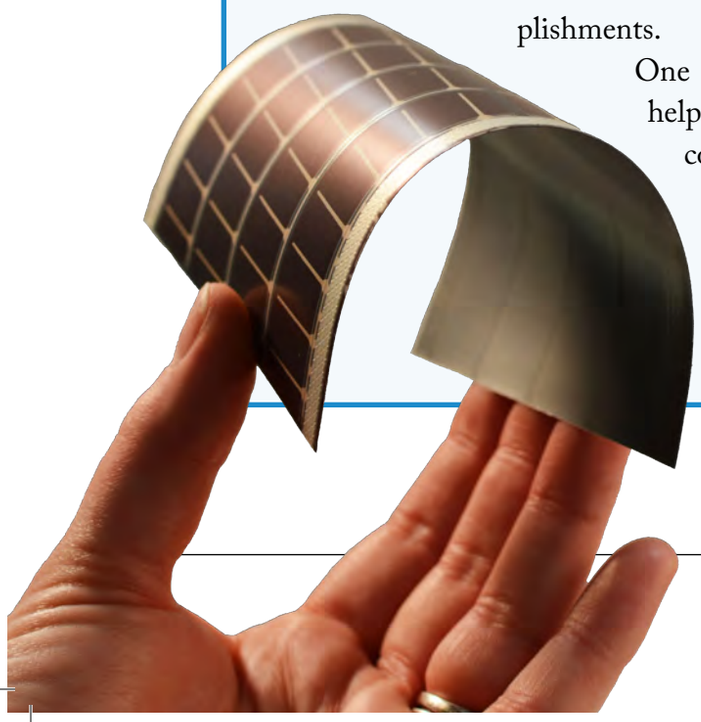
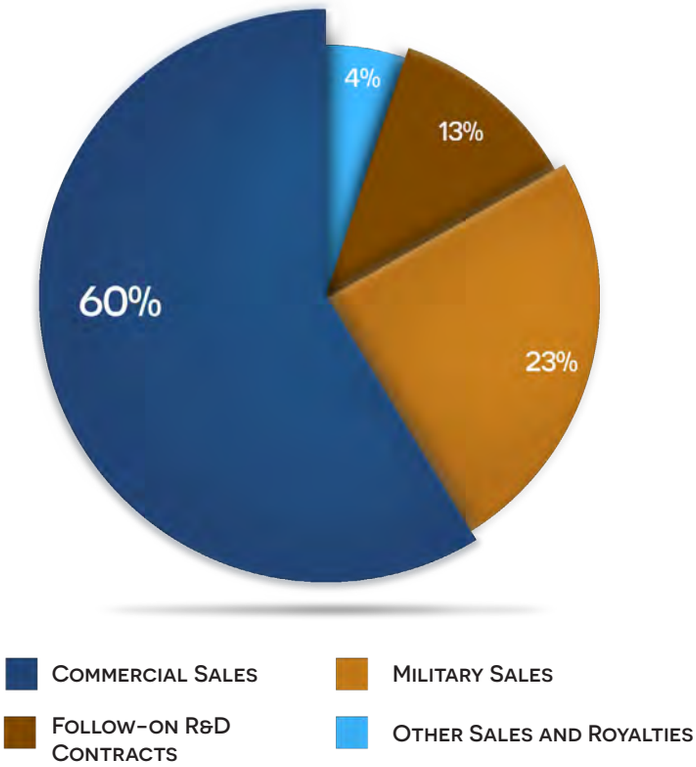


Figure 1. Sales Results by Sales Category



The most productive SBIR/STTR Phase II contract generated well over $20 billion in total combined U.S. sales relevant to this study. This amount was significantly larger than the second most successful Phase II contract, which had approximately a third of that value. Both of these uncommonly successful contracts were outliers. However, many contracts yielded significant returns. A total of eleven contracts generated sales in excess of $1 billion; 21 had sales greater than $500 million; 116 had sales of more than $100 million; 1,024 had sales of $10 million or more; and 5,036 had sales greater than $846,158, which was the average size of the individual DoD SBIR/STTR Phase II contracts.

Sales Figures Understate the Reality. For several reasons, total sales figures obtained by this survey are probably significantly smaller than the actual total sales resulting from DoD SBIR/STTR Phase II contracts initiated during the FY 1995-2012 period. Reasons include the following:

- *Non-responding companies*. As previously noted, 298 companies did not participate in the study—126 because they declined to participate, and another 172 that could

not be contacted despite extensive research. Many of the non-compliant companies are believed to have substantial sales. For example, a sizeable number were large corporations that had acquired Phase II recipient companies because of the commercial strength of the technologies developed with DoD SBIR/STTR funding.

- *Licensee sales information generally unavailable.* The total sales figures also underreport the reality because they do not include most of the licensee sales. Companies reported that they had licensed technologies resulting from 725 of their Phase II contracts. However, the TechLink team was able to obtain sales information for only 177 (24 percent) of these contracts. Many companies declined to identify their licensees or to divulge what they knew of licensee sales. In cases where the licensees were identified and contact information was provided, the licensees often proved to be resistant. For the most part, licensees did not feel obligated to participate in this study and were not responsive to requests for information on their sales.

- *Licensee underreporting of sales and underpayment of royalties.* Another reason why the total reported sales, as well as the royalties from such sales, are believed to be substantially larger than this survey discovered is that underreporting is common in the licensing world. Historic royalty audit data from the Invotex Group, a well-established accounting and intellectual property management company, reveals that over 80 percent of licensees underreport and underpay royalties to their licensors.[20] There are various reasons why royalties are underreported. However, the Invotex Group found that at least half of the licenses it audited had underreported sales.

- *Sales information for spin-out companies generally unavailable.* The total sales figures do not include many of the sales by companies spun out of the Phase II recipient companies to commercialize technologies developed with DoD SBIR/STTR funding. A total of 327 spin-out companies were reportedly created. However, the TechLink team was able to obtain sales information for only 133 of these companies (41 percent). As in the case of licensees, the majority of the spin-out companies did not feel obligated to participate in this study and were not responsive to requests for information on their sales.

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20 D.R. Stewart and J.A. Byrd, "The Significance of Underreported Royalties-2007 Update: The Magnitude and Meaning of Royalty Misreporting," Invotex Group, Baltimore, MD, February 2007, online at *www.lawseminars.com/materials/07LICIL/licil%20m%20stewart2.pdf*; D.R. Stewart and J.A. Byrd, "89% of Royalty Revenue is Underreported! Top Five Questions You Should Ask Your Licensee to Avoid Becoming a Statistic," Invotex Group, Baltimore, MD, April 2012, online at *www.invotex.com/assets/2012_Royalty_Audit_Article.pdf*.

- *Classified or highly proprietary information.* Given that one of the primary goals of the DoD SBIR/STTR Program is to support military needs, many projects involved classified applications, and companies were reluctant to provide sales data or were expressly prohibited from doing so. Also, many companies or their SBIR-derived capabilities were acquired by large prime contractors and these small businesses were not allowed to disclose (or did not know) the resultant sales figures. In these situations, when it was known that sales occurred, a nominal value of $1 was assigned—even though, in some cases, sales were believed to be in the billions of dollars.

- *Inflation.* Finally, inflation contributes to an under-valuation of earlier sales in this study. There were no adjustments for inflation. All sales figures were aggregated, and the timing of sales by year is not known. Some sales date back to the late 1990s. Aggregation of company sales values does not preserve the relatively higher value of sales that occurred earlier in the study period. For example, $100 in 1998 had the same purchasing power as $155 in 2018.

For all of the above reasons, the total sales figures reported in this survey are conservative and substantially understate the actual total sales resulting from DoD Phase II contracts initiated during the FY 1995-2012 period. In addition, the study included only sales that could be *directly*

SBIR Success Story

An outdoor recreation company in Washington state creates water-purification solutions

In 2008, Seattle-based Mountain Safety Research (MSR) responded to a U.S. Army SBIR solicitation. The Department of Defense was interested in water treatment devices that troops in the field could use easily and efficiently. MSR developed a single-pass, state-of-the-art "ultra-filtration" individual water treatment device (IWTD) that removes viral as well as bacterial hazards. In the end, two different products were designed—one for the military and another, the MSR Guardian hand-pump purifier, for the outdoor market.

attributed to the DoD SBIR/STTR-funded projects. Some of the DoD-funded projects resulted in major technological advances, such as new CMOS imaging sensors and Bluetooth chips, that have been responsible for vastly larger economic impacts by enabling a profusion of new products and capabilities.

Other Economic Outcomes and Impacts

In addition to sales, the companies in the study reported other significant economic outcomes and impacts. *Total outside investment funding* (including venture capital and angel funding) directly related to the innovations developed with DoD SBIR/STTR Phase II contracts was reported to be approximately $9.5 billion. The *number of companies acquired* primarily because of the technology developed with DoD SBIR/STTR funding was 496, with a total acquisition value reported to be around $35.6 billion. However, this figure grossly understates the actual value. Over 40 percent of the acquired companies stated that the terms of acquisition prevented them from disclosing the acquisition amount. Finally, companies in the study reported that 725 of their Phase II contracts resulted in *licenses to other companies*, and companies reported that they had created a total of 327 *spin-out companies* specifically to commercialize technologies developed with DoD SBIR/STTR Phase II funding. These other economic outcomes and impacts are summarized below:

$9.5 BILLION
Total reported outside investment funding

496
Number of companies that were acquired

$35.6 BILLION
Total reported acquisition value of companies acquired

725
Number of contracts resulting in licenses to other companies

327
Number of spin-out companies created

NATIONAL-LEVEL ECONOMIC IMPACT ANALYSIS

Upon receiving the company sales and six-digit NAICS code data from TechLink, the BRD at the Leeds School of Business, University of Colorado Boulder, used the national IMPLAN input-output model to quantify the overall economic impacts resulting from the sales of new products and services.[21] The BRD undertook this task in two stages: (1) IMPLAN analysis of the economic impacts resulting from the DoD SBIR/STTR R&D activity, which totaled nearly $16 billion[22]; and (2) IMPLAN analysis of the $121 billion in sales of the innovations resulting from this R&D. Results below are presented for *output, employment, labor income*, *value added*, and *tax revenues*. As previously noted, all monetary figures are reported in 2017 dollars.

21 The research team used the 2016 IMPLAN model, which was the most recent model available during the economic impact analysis phase of this project.

22 $15.97 billion, which includes both the $14.35 billion in Phase II awards and the initial Phase I awards to these same companies totaling $1.62 billion.

Total Economic Impact (Output): $347.3 Billion

Output is the total value of all goods or services (including intermediate goods and services) produced during a given time period, whether used for further production or consumed. The concept of national output is an integral part of macroeconomics. Output is closely associated with economic impact analysis and is one of the values most frequently cited by economic impact studies. It represents the total economic impact.

IMPLAN modeling estimated a total of $347.28 billion in economic output from the DoD SBIR/STTR awards in this study. The key components of this total were $137.01 billion in direct effects, $96.96 billion in indirect effects, and $113.31 billion in induced effects. The following paragraphs break these totals down first by the DoD SBIR/STTR R&D activity, and second by the subsequent sales of DoD SBIR/STTR Phase II innovations.

DoD SBIR/STTR R&D Activity. According to the national IMPLAN model, the nearly $16 billion in DoD SBIR/STTR R&D contracts (both Phase I and II) provided to small businesses nationwide generated nearly $43 billion in economic output from the R&D activities alone. Of this amount, approximately $11 billion was generated indirectly as the result of inter-industry purchases (firms purchasing from each other), and nearly $16 billion was generated from the induced effect, the result of households spending payroll on goods and services economy-wide (see Table 4).

Dividing the economy-wide output ($42.84 billion) by the direct value of the DoD SBIR/STTR Phase I and II R&D contracts ($16 billion) yields an output multiplier of 2.68. That is, for every dollar in economic activity directly attributable to the DoD SBIR/STTR Phase II R&D, an *additional* $1.68 in economic activity was generated nationwide.

Table 4. Economic Impact of DoD SBIR/STTR R&D Activity

Impact Type	Employment (Job Years)	Labor Income ($ Billions)	Labor Income (Per Job)	Value Added ($ Billions)	Output ($ Billions)
Direct Effect	59,968	$6.28	$104,685	$8.65	$15.97
Indirect Effect	66,336	$4.27	$64,329	$6.83	$11.01
Induced Effect	97,219	$4.99	$51,295	$8.86	$15.86
Total	223,523	$15.53	$69,487	$24.33	$42.84

Source: Business Research Division, Leeds School of Business, University of Colorado, Boulder; 2016 IMPLAN National Model

Note: Totals may not tally due to rounding

Sales of DoD SBIR/STTR Phase II innovations. In addition to the economic output from the SBIR/STTR R&D, this study examined the output from the subsequent sales of the innovations resulting from this R&D. According to the national IMPLAN model, the $121 billion in direct sales of new products and services reported by companies generated an additional $183 billion in impact economy-wide. Of this amount, nearly $86 billion was generated indirectly as the result of inter-industry purchases, and slightly over $97 billion was generated from households spending their payroll on goods and services (the induced effect). The total economy-wide output from sales of the DoD SBIR/STTR Phase II-developed technology was slightly over $304 billion (see Table 5).

Table 5. Economic Impact of Subsequent Company Sales

Impact Type	Employment (Job Years)	Labor Income ($ Billions)	Labor Income (Per Job)	Value Added ($ Billions)	Output ($ Billions)
Direct Effect	300,540	$36.75	$122,285	$60.39	$121.05
Indirect Effect	387,029	$27.88	$72,031	$44.79	$85.95
Induced Effect	597,203	$30.64	$51,304	$54.42	$97.45
Total	1,284,772	$95.27	$74,152	$159.59	$304.44

Source: Business Research Division, Leeds School of Business, University of Colorado, Boulder; 2016 IMPLAN National Model

Note: Totals may not tally due to rounding

Dividing total economy-wide output ($304 billion) by the direct sales of products and services related DoD SBIR/STTR Phase II contracts ($121 billion) yields an output multiplier of 2.52. For every dollar in sales directly attributable to the DoD SBIR/STTR Phase II contracts, an *additional* $1.52 in sales was generated economy-wide.

Value Added: $183.9 Billion

Value added is the difference between a company's output and the cost of intermediate inputs. In other words, it is the difference between a product's sale price and its production cost. This measure recognizes that companies buy goods and services from other companies in

order to create products of greater value than the sum of the goods and services used to make these products. This increase in value resulting from the production process is the "value added." As estimated by IMPLAN, value added is equal to the total sales (plus or minus inventory adjustments) minus the cost of the goods and services purchased to produce the products sold.

The main difference between output and value added is that output includes the value of intermediate goods and services, while value added does not. Many economists prefer value added as an economic measure because, at the macroeconomic scale, output multiple-counts the value of inputs.

For example, in the previously cited case of the hypothetical company, TranXistor, which sells an ultra-high-performance carbon nanotube transistor developed with its DoD SBIR/STTR Phase II contract: The company purchases industrial machines, electronic components, and specialized equipment and supplies to make the transistors. The value of its sales incorporates the value of these various inputs. Further, each of the companies from which TranXistor purchases its inputs incorporates the value of their respective inputs from other companies.

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The research team found that the total value added resulting from the DoD SBIR/STTR awards in this study was $183.93 billion. The key components of this total were $69.03 billion in direct effects, $51.61 billion in indirect effects, and $63.28 billion in induced effects (see Table 6). The following paragraphs break these totals down first, by the DoD SBIR/STTR R&D activity, and second, by the subsequent sales of DoD SBIR/STTR Phase II innovations.

DoD SBIR/STTR R&D Activity. According to the national IMPLAN model, the initial nearly $16 billion in SBIR/STTR contracts generated slightly over $24 billion in value added impact economy-wide for the R&D activities alone. Of this total, approximately $8.6 billion was generated directly, $6.8 billion was generated indirectly, and $8.9 billion was generated from the induced effect (see Table 4).

Sales of DoD SBIR/STTR Phase II innovations. Subsequent IMPLAN analysis estimated that the $121 billion in sales reported by companies generated nearly $160 billion in value added impact economy-wide: $60.4 billion generated directly; $44.8 billion indirectly; and $54.4 billion from the induced effect (see Table 5).

Employment: **1,508,295 Jobs Total** (65,578 average per year)

Employment in this analysis is an estimate of the number of jobs supported by the estimated level of output and is expressed in "job years" (one job supported for a year). The research team found that the total employment resulting from the DoD SBIR/STTR awards in this study was 1,508,295 job years, or an average of 65,578 jobs per year over the 23-year period from 1995-2017. The key components of this total were 360,508 job years (15,674 average jobs per year) in direct effects, 453,365 job years (19,712 average jobs per year) in indirect effects, and 694,422 job years (30,192 average jobs per year) in induced effects. The following paragraphs break these totals down first, by the DoD SBIR/STTR R&D activity, and second, by the subsequent sales of DoD SBIR/STTR Phase II innovations.

DoD SBIR/STTR R&D Activity. The national IMPLAN model estimated that nearly 60,000 job years, an average of 2,998 jobs per year,[23] were directly created economy-wide by the $16 billion in R&D activity. Indirect effects were responsible for an additional 66,336 job years (3,317 jobs per year), and induced effects for 97,219 job years (4,227 jobs per year). The IMPLAN model estimates that, altogether, nearly 224,000 job years nationwide (an average of 11,176 jobs per year) resulted from the direct, indirect, and induced effects of the DoD SBIR/STTR R&D activity during the funded period (see Table 4).

Sales of DoD SBIR/STTR Phase II innovations. According to the national IMPLAN model, the $121 billion in sales directly supported an estimated 300,540 job years economy-wide, or 13,067 (average) jobs per year. Indirect effects were responsible for an additional 387,029 job years (16,827 jobs per year), and induced effects for 597,203 job years (25,965 jobs per year). The IMPLAN model estimates that, altogether, 1,284,772 job years nationwide, or an average of 55,860 jobs per year, resulted from the direct, indirect, and induced effects of the sales of DoD SBIR/STTR Phase II innovations (see Table 5).

Labor Income: **$110.8 Billion** ($73,461 per job)

Labor income consists of employee compensation (wage and salary payments, including benefits), paid to workers as well as proprietor income (income received by self-employed individuals).

The research team found that the total labor income resulting from the DoD SBIR/

23 During the period of Phase II funding, 1995-2014

STTR awards in this study was $110.8 billion. The key components of this total were $43.03 billion in direct effects, $32.15 billion in indirect effects, and $35.63 billion in induced effects. Broken down by the labor income or average compensation per job, the totals were $119,357 compensation per job in the direct effects category, $70,904 compensation per job in the indirect effects category, and $51,302 compensation per job in the induced effects category. The following paragraphs break these totals down first, by the DoD SBIR/STTR R&D activity, and second, by the subsequent sales of DoD SBIR/STTR Phase II innovations.

DoD SBIR/STTR R&D Activity. The national IMPLAN model estimated that the direct labor income associated with the roughly $16 billion in SBIR/STTR R&D activity was nearly $6.3 billion, or approximately $104,685 per job (see Table 4). For comparison, the annualized median wage in the U.S. in 2017 was $44,694.[24] The indirect labor income was estimated at nearly $4.3 billion, or approximately $64,329 per job. The induced labor income was estimated to be nearly $5 billion, or $51,295 per job. Average wages for the indirect and induced jobs were substantially lower than the average wage for the jobs directly created by the R&D activity because many of these indirect and induced jobs were in lower-paid manufacturing and service sectors. The total economy-wide labor income resulting from the DoD SBIR/STTR R&D activity was $15.53 billion. The average wage of the estimated 223,523 jobs created as a result of the DoD SBIR/STTR R&D activity was $69,487—approximately 55 percent higher than the 2017 median U.S. wage of $44,694.

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Sales of DoD SBIR/STTR Phase II innovations. According to the national IMPLAN model, the direct labor income associated with the $121 billion in sales reported by companies was nearly $37 billion, or $122,285 per job (see Table 5). This was more than 2.7 times the median U.S. wage in 2017. The indirect labor income was estimated at nearly $28 billion, or approximately $72,031 per job. The induced labor income was estimated to be nearly $31 billion, or $51,304 per job. The total economy-wide labor income resulting from sales of the DoD SBIR/STTR Phase II innovations was slightly over $95 billion. The average wage of the estimated 1,284,772 job years created as a result of sales of the DoD SBIR/STTR Phase II innovations was $74,152, which is 66 percent higher than the 2017 median U.S. wage.

24 This estimate is derived from U.S. Bureau of Labor Statistics' average weekly earnings data for 2017, available at *http://www.bls.gov*.

Tax Revenues: $39.4 Billion Total

Tax revenues generated by the DoD SBIR/STTR Program were estimated for the $16 billion in DoD SBIR/STTR activity and $121 billion in subsequent sales, including their associated economy-wide indirect and induced effects. These tax revenues included social insurance taxes such as Social Security and Medicare (paid by employers, employees, and the self-employed), personal income taxes, motor vehicle licenses, property taxes, corporate profits taxes and dividends, and indirect business taxes, comprised mainly of excise and property taxes, fees, licenses, and sales taxes.

Total taxes collected by federal, state, and local government entities were estimated at $39.42 billion. This included $13.48 billion in tax revenues from the direct effects of both the R&D activity and the subsequent commercial activity, $11.22 billion from indirect effects, and $14.72 billion from induced effects.

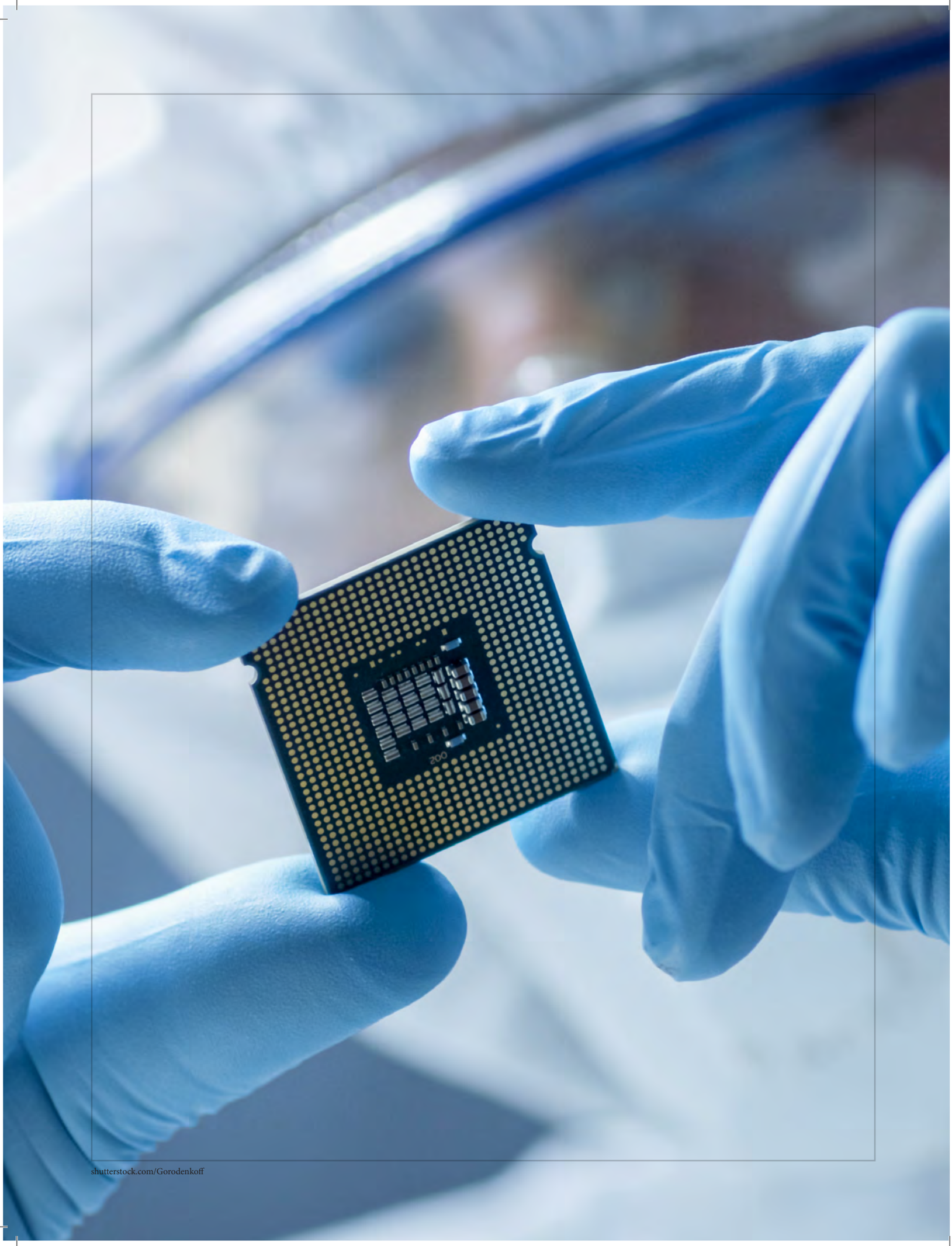
Table 6 summarizes the results from the national-level economic impact analysis of the DoD SBIR/STTR Program, providing a breakdown of the direct, indirect, and induced effects for employment, labor income, value added, output, and tax revenues. **Appendix 2 provides a state-level breakdown** of this program's economic output, as determined by IMPLAN modeling, showing the results for all 50 states and the District of Columbia.

Table 6. Nationwide Economic Impacts from DoD SBIR/STTR Program

Impact Type	Employment (Job Years)	Employment (Av. Per Year)	Labor Income ($ Billions)	Labor Income (Per Job)	Value Added ($ Billions)	Output ($ Billions)	Tax Revenue ($ Billions)
Direct Effect	360,508	15,674	$43.03	$119,357	$69.03	$137.01	$13.48
Indirect Effect	453,365	19,712	$32.15	$70,904	$51.61	$96.96	$11.22
Induced Effect	694,422	30,192	$35.63	$51,302	$63.28	$113.31	$14.72
Total	1,508,295	65,578	$110.80	$73,461	$183.93	$347.28	$39.42

Source: Business Research Division, Leeds School of Business, University of Colorado Boulder; 2016 IMPLAN National Model

Note: Totals may not tally due to rounding



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SUMMARY

This study's purpose was to quantify the DoD SBIR/STTR Program's overall contribution to the U.S. economy and defense mission. It examined the economic outcomes and impacts up to 2018 of DoD SBIR/STTR Phase II contracts initiated from FY 1995 through 2012. This time period includes all Phase II awards since 1995 that realistically could have generated any significant sales by the time of the study. A total of 16,959 contracts, involving 4,412 companies, were included.

The research team asked companies about sales of new products and services directly related to their DoD SBIR/STTR Phase II contracts. Companies were also asked about sales to the U.S. military (either directly or through a defense contractor) as well as follow-on R&D contracts, licensing revenue, and sales by licensees and spin-out companies. Companies provided comprehensive information on the economic outcomes for 96 percent of the contracts. Through secondary sources, the research team obtained information on many others. In all, this study presents the economic outcomes for over 97 percent of the DoD SBIR/STTR Phase II contracts.

Well over half of the contracts—58 percent—resulted in sales of new products and services. Companies reported $121 billion in total

sales and $27.5 billion in military product sales. These numbers are very conservative for reasons discussed in the report. Also, the study included only sales that could be *directly* attributed to the DoD SBIR/STTR-funded projects. Some of the projects resulted in major technological advances, such as new CMOS imaging sensors and Bluetooth chips, that have enabled vastly larger economic impacts. Other significant economic outcomes from the DoD SBIR/STTR contracts include outside investment funding of over $9.5 billion, 725 contracts that resulted in technology licenses to other companies, and a total of 327 new companies created to produce and sell the SBIR/STTR-developed innovations.

IMPLAN economic impact assessment software was used to estimate the total economic impacts related to both the SBIR/STTR R&D activity and subsequent sales of new technologies developed with this R&D. Impacts analyzed included economic output, value added, employment, labor income, and tax revenues.

The total economy-wide impact from the DoD SBIR/STTR Program was determined to be slightly over $347 billion. This represents an impressive **22:1 economic return** on the program's investment in small business R&D.[25] Other significant outcomes include the creation or sustainment of 1,508,295 jobs—an average of 65,578 jobs per year; total labor income of $111 billion, resulting in average compensation of $73,461 for each job supported; and over $39 billion in combined federal, state, and local tax revenues.

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25 $347 billion divided by $15.97 billion, which includes both the $14.35 billion in Phase II awards and the initial Phase I awards to these same companies totaling $1.62 billion. Neither outside investments nor acquisition values are included in these figures.

STTR Success Story

Created with help from a Navy STTR, the Slocum glider slips autonomously through the world's oceans, harvesting data

The Slocum Glider has a wide variety of applications, academic to commercial to military. In applications such as deep-water monitoring and hydrocarbon detection and measurement, it provides a safer, more affordable alternative to ship-based operations. The gliders can perform for months with minimal oversight, collecting data and providing situational awareness.

APPENDICES

Appendix 1. NAICS Codes Assigned to Contracts in the Study

The following 36 NAICS codes account for 95 percent of the total direct income from the DoD SBIR/STTR Program awards covered in this study (with the remaining 5 percent consisting of 158 additional codes):

Table 1A: Most Frequent NAICS Codes for DoD SBIR/STTR-Related Activities

NAICS Code	Description
334413	Semiconductor and Related Device Manufacturing
541715	R&D in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing
541511	Custom Computer Programming Services
334519	Other Measuring and Controlling Device Manufacturing
336411	Aircraft Manufacturing
334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
511210	Software Publishers
327999	All Other Miscellaneous Nonmetallic Mineral Product Manufacturing
336414	Guided Missile and Space Vehicle Manufacturing
541512	Computer Systems Design Services
334419	Other Electronic Component Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables
333314	Optical Instrument and Lens Manufacturing
333242	Semiconductor Machinery Manufacturing
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing
325413	In-Vitro Diagnostic Substance Manufacturing
334310	Audio and Video Equipment Manufacturing
541330	Engineering Services
332993	Ammunition (except Small Arms) Manufacturing
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing
336611	Ship Building and Repairing
336412	Aircraft Engine and Engine Parts Manufacturing
336992	Military Armored Vehicle, Tank, and Tank Component Manufacturing
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing

333316	Photographic and Photocopying Equipment Manufacturing
339113	Surgical Appliance and Supplies Manufacturing
325211	Plastics Material and Resin Manufacturing
333318	Other Commercial and Service Industry Machinery Manufacturing
325510	Paint and Coating Manufacturing
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing
335312	Motor and Generator Manufacturing
334210	Telephone Apparatus Manufacturing
327910	Abrasive Product Manufacturing

Appendix 2. State-level Analysis of DoD SBIR/STTR Program Economic Impacts

Table 2A lists award statistics for all 50 states and the District of Columbia, ranked according to the DoD SBIR/STTR Program's total impact on each.[26] "Companies with Sales" are those reporting sales of any type, including product or service sales, follow-on research and development funding, spinoff sales, or licensee sales (including royalties). Phase II funding and total direct sales are the direct inputs modeled by IMPLAN, and total impact (output) is the result of the IMPLAN modeling.

Table 2A: DoD SBIR/STTR Program Economic Impacts by State

Rank	State	Companies with Sales	Phase II Award Count	Phase II Funding ($ Millions)	Total Direct Sales ($Millions)	Total Impact (Output) ($Millions)
1	CA	575	3,493	2,928	61,385	126,365
2	MA	239	2,296	1,959	6,572	18,897
3	VA	193	1,420	1,250	7,196	17,570
4	TX	100	689	585	1,308	14,734
5	NY	134	731	615	2,713	13,545
6	PA	116	744	615	4,024	12,956
7	WA	59	297	249	6,421	12,014
8	OH	130	788	673	1,940	9,780

26 There were no DoD SBIR/STTR Phase II awards to companies in Puerto Rico during the study period.

Rank	State	Companies with Sales	Phase II Award Count	Phase II Funding ($ Millions)	Total Direct Sales ($Millions)	Total Impact (Output) ($Millions)
9	AZ	57	328	273	3,391	9,726
10	CO	127	740	654	3,230	9,092
11	MD	126	823	684	2,780	7,546
12	MI	82	366	325	2,101	7,205
13	FL	106	471	397	1,377	6,904
14	IL	55	241	204	775	6,809
15	NJ	84	462	375	1,524	6,486
16	CT	45	238	186	1,729	5,178
17	AL	60	463	393	1,565	5,040
18	OR	24	109	95	890	4,513
19	NC	37	161	128	710	4,339
20	UT	31	114	95	1,265	4,223
21	MN	35	194	149	846	3,885
22	GA	35	176	145	392	3,847
23	IN	29	106	87	432	3,841
24	NH	28	242	223	1,494	3,606
25	TN	20	104	87	149	2,650
26	WI	20	80	63	114	2,440
27	NM	52	270	237	916	2,335
28	MO	22	66	48	275	2,260
29	LA	5	21	17	70	2,224
30	OK	14	53	45	509	1,998
31	DE	9	46	34	884	1,881
32	SC	13	45	36	160	1,871
33	KY	6	11	8	17	1,396
34	IA	10	23	16	52	1,273

Rank	State	Companies with Sales	Phase II Award Count	Phase II Funding ($ Millions)	Total Direct Sales ($Millions)	Total Impact (Output) ($Millions)
35	WV	9	41	36	288	1,128
36	NV	20	75	60	135	1,086
37	AR	7	27	21	44	1,054
38	KS	4	29	21	15	1,052
39	ID	9	31	27	160	987
40	NE	4	36	32	109	975
41	HI	19	58	54	326	846
42	MS	6	20	15	103	830
43	RI	11	61	58	180	775
44	ME	12	41	39	141	598
45	MT	17	50	39	152	576
46	DC	5	14	12	10	519
47	VT	9	31	29	96	439
48	WY	7	16	13	12	343
49	SD	4	6	5	22	342
50	ND	5	8	7	25	322
51	AK	2	4	4	25	276

Methodology for State-level Analysis

The Leeds School of Business at the University of Colorado Boulder used the IMPLAN model to determine two ways in which a single state's economy responded to DoD SBIR/STTR-related spending: (1) The business activity of SBIR/STTR companies within that state's borders; and (2) the indirect and induced effects of SBIR/STTR company activity in other states.

When IMPLAN calculates the effects of regionally specific spending in a given industry, it accounts for "leakages." These are dollars that exit the specified economy when purchases are made elsewhere. Leakages include indirect effects such as purchases of components and supplies from neighboring states and foreign countries, and also employment and wages paid to workers commuting across borders. They also include induced effects outside the state, such as from

employee vacations and online retail spending.

IMPLAN uses U.S. government data on supply chains and business patterns to estimate the effects of this leakage on other states. For example, if a company in Massachusetts needs steel for its manufacturing operations, it will likely buy ingots or processed steel parts from an out-of-state supplier. IMPLAN estimates both the portion of the demand for steel met by Massachusetts companies and the portion that leaks from the state economy. If another state, such as Indiana, supplies steel to the Massachusetts company, that will show up as an indirect effect on Indiana's economy.

To determine the state-level impact estimates, economists at the University of Colorado Boulder used a technique called Multi-Regional Input-Output (MRIO) analysis. First, they analyzed the economic contributions of each state's recipient DoD SBIR/STTR awardee companies. Next, they analyzed the indirect and induced effects, on each state, of DoD SBIR/STTR spending in the other 49 states and the District of Columbia. Finally, they aggregated the results from the two preceding operations to show a state's total estimated benefit from the DoD SBIR/STTR Program—the total economic impact on that state.

SBIR Success Story

SBIR Delivers New Intercommunications System for E-2 Hawkeye

The U.S. Navy's E-2 Hawkeye, an all-weather twin-turboprop aircraft, is designed to provide early warning for other craft as well as wide-ranging sea and land surveillance capabilities. A staple on aircraft carriers, the Hawkeye has been continuously deployed by the Navy since the Vietnam war, as well as used in domestic civilian relief efforts. But by the late nineties, its communications system was becoming outdated. With Navy SBIR funding, Virginia-based Mathtech developed an updated Intercommunications System. In 2013, Mathtech was awarded a production contract with the Navy and has since built and delivered new Intercommunications Systems for nearly 50 of the latest generation of the Hawkeye aircraft, the E-2D.

https://sbir.defensebusiness.org

http://techlinkcenter.org

NATIONAL ECONOMIC IMPACTS

From the DoD SBIR/STTR Program

1995–2018

DoD's investment of **$14.4 billion** in small business R&D resulted in:

22:1
RETURN ON THE DoD INVESTMENT

$121
BILLION
IN TOTAL SALES OF NEW PRODUCTS AND SERVICES

$28
BILLION
IN SALES OF NEW PRODUCTS TO THE U.S. MILITARY

$347
BILLION
IN TOTAL ECONOMIC IMPACT NATIONWIDE

1,508,295
JOBS (65,578 PER YEAR) WITH AVERAGE COMPENSATION OF $73,461